MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2018/2019

ETN2016 – ANALOG COMMUNICATIONS

(All Section / Groups)

12 MARCH 2019
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 8 pages (including the cover page) with 4 Questions only.

2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Consider a periodic signal $s(t)$ shown in Figure Q1.1.

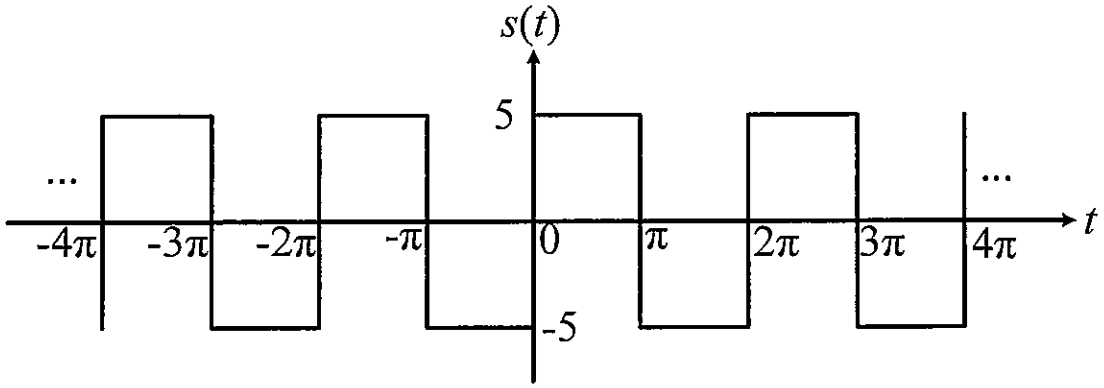

Figure Q1.1: Periodic signal $s(t)$.

(i) Determine the trigonometric Fourier series of $s(t)$.

[11 marks]

(ii) Sketch the single-sided magnitude spectrum of $s(t)$ up to the 5th harmonic, i.e., $n = 0, 1, 2, 3, 4, 5$, where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $s(t)$.

[3 marks]

(iii) Sketch the double-sided phase spectrum of $s(t)$ for $n = -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5$, where $f = nf_0$ is the nth harmonic frequency, $f_0 = \frac{1}{T_0}$, and T_0 denotes the period of $s(t)$.

[3 marks]

(b) Consider a signal $y(t) = 8e^{-5t}u(t)$, where $u(t)$ denotes unit step function.

(i) Determine the Fourier transform of $y(t)$.

[4 marks]

(ii) Determine the Fourier transform of $z(t) = y(-t)$.

[4 marks]

Continued .....

Question 2

(a) Explain three advantages of bandpass modulation.

[6 marks]

(b) A message signal $m(t)=A_m\cos(2\pi f_m t)$ amplitude-modulates a carrier signal $c(t)=A_c\cos(2\pi f_c t)$, resulting in an amplitude modulated signal $s(t)$ that is expressed as follows:

$$s(t)=A_c\cos(2\pi f_c t)+\frac{A_c\mu}{2}\cos[2\pi(f_c+f_m)t]+\frac{A_c\mu}{2}\cos[2\pi(f_c-f_m)t],$$

where μ is the modulation factor. Assume that $A_m=10$ V, $f_m=25$ kHz, $A_c=20$ V, $f_c=900$ kHz, $\mu=0.6$, and $s(t)$ is supplied to a load of 100 ohms.

(i) Calculate the power contained in the upper sideband of $s(t)$.

[3.5 marks]

(ii) Compute the total power dissipated across the load due to $s(t)$.

[3.5 marks]

(iii) Suggest a method to recover the message signal from $s(t)$.

[1 mark]

(c) A message signal $v(t)=2\cos(200\pi t)$ is applied to a double sideband suppressed carrier (DSB-SC) modulator with carrier signal $c(t)=2\cos(800000\pi t)$.

(i) Derive the frequency domain expression for the DSB-SC modulated signal.

[4 marks]

(ii) Sketch the magnitude spectrum of the DSB-SC modulated signal.

[3 marks]

(iii) State one advantage of DSB-SC modulation scheme in comparison to double sidebands large carrier (DSB-LC) modulation scheme.

[1 mark]

(d) Does DSB-SC modulation scheme use coherent or noncoherent demodulation? Justify your answer.

[3 marks]

Continued .....

Question 3

(a) Consider a frequency modulated signal that is expressed as follows:

$$p(t)=6\cos\left\{(2\pi)(1.8\times10^{6}t)+5\sin(3\times10^{3}\pi t)\right\}$$

Assume that $p(t)$ is supplied to a load of 1 ohm.

(i) Determine the modulation index.

[1 mark]

(ii) By using the Carson's rule, calculate the bandwidth of $p(t)$.

[3 marks]

(iii) Calculate the average power of $p(t)$.

[2 marks]

(iv) By using the table of Bessel function of the first kind, compute the amount of transmission power that falls in the sideband.

[3 marks]

(v) The frequency modulated signal $p(t)$ is passed through an ideal bandpass filter with center frequency of 1.8 MHz, bandwidth of 10 kHz, and unity gain. Determine the number of sidebands that will pass through the bandpass filter without being attenuated and the average power measured at the output of the filter.

[6 marks]

(b) State one advantage and one disadvantage of generating frequency modulated signal using direct method.

[2 marks]

(c) With the aid of diagrams, discuss in detail the purposes and working principles of pre-emphasis and de-emphasis filtering used in a frequency modulation (FM) system.

[5 marks]

(d) As a driver is travelling along a highway from town A to town B, he tunes his FM receiver to play songs broadcasted by FM station X. However, about the midway, he notices that his FM receiver is alternatively tuning in to stations X and Y for approximately 10 minutes. As he drives nearer to town B, his FM receiver is now playing songs broadcasted by FM station Y. Explain the reason for this observation.

[3 marks]

Continued .....

Question 4

(a) Figure Q4.1 shows the block diagram of an amplitude modulation (AM) receiver. $x(t)=s(t)+n(t)$ is the input to the envelope detector, where $s(t)=A_c\left[1+k_a m(t)\right]\cos(2\pi f_c t)$ is the amplitude modulated signal, $n(t)$ represents the white noise with power spectral density of $\frac{N_0}{2}$, $A_c\cos(2\pi f_c t)$ is the carrier signal, $m(t)$ is the message signal with bandwidth of W, and k_a is the amplitude sensitivity of the modulator. Assume that the band-pass filter has unity gain and an equivalent noise bandwidth of B_T, $E\left[m(t)\right]=0$, and $P=E\left[m^2(t)\right]$, where $E[\ ]$ is the expectation operator.

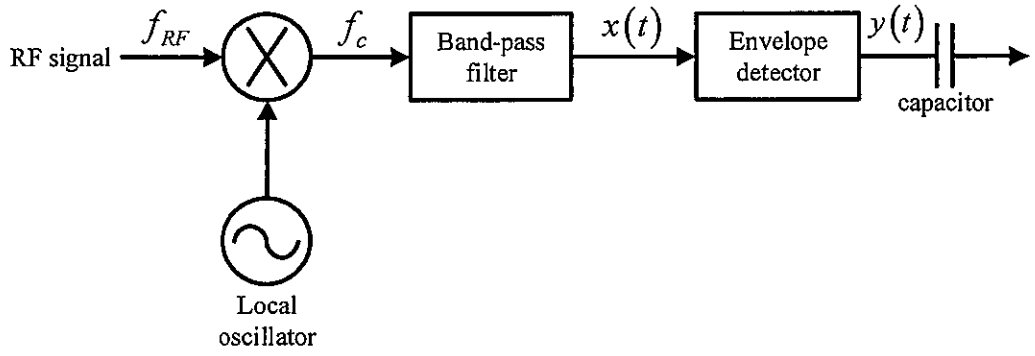

Figure Q4.1: Block diagram of an AM receiver.

Derive the expressions for the following:

(i) Signal-to-noise ratio (SNR) at the input of the envelope detector.

[7 marks]

(ii) Output signal of the envelope detector $y(t)$ under high SNR conditions.

[5 marks]

(b) Design a superheterodyne frequency modulation (FM) radio receiver that can be tuned to receive FM broadcasts from 88 MHz to 108 MHz with an intermediate frequency (IF) of 12.7 MHz by using high-side injection (high tracking).

(i) Calculate the range of frequencies that must be generated by the local oscillator (LO).

[3 marks]

(ii) Compute the range of image frequencies.

[3 marks]

(iii) Determine the LO frequency and the image frequency when the receiver is tuned to a station at 98 MHz.

[3 marks]

(iv) Calculate the image rejection ratio (IRR) in dB if the image rejection filter consists of a tuned circuit with quality (Q) factor of 50 and the receiver is tuned to a station at 98 MHz.

[4 marks]

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APPENDIX

Fourier Transform Pairs

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t-t_o)$	$e^{-j2\pi ft_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f-f_o)$
$u(t)$	$\frac{1}{2}\delta(f)+\frac{1}{j2\pi f}$
$e^{-at}u(t)$	$\frac{1}{a+j2\pi f}$, for $a>0$
$e^{at}u(-t)$	$\frac{1}{a-j2\pi f}$, for $a>0$
$e^{-a\lvert t\rvert}$	$\frac{2a}{a^2+(2\pi f)^2}$, for $a>0$
$rect\left(\frac{t}{T}\right)$	$T\text{sinc}(fT)$
$\text{sinc}(2Wt)$	$\frac{1}{2W}rect\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2}\text{sinc}^2\left(\frac{fT}{2}\right)$
$W\text{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$
$\cos(2\pi f_o t)$	$\frac{1}{2}\delta(f-f_o)+\frac{1}{2}\delta(f+f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j}[\delta(f-f_o)-\delta(f+f_o)]$

Continued .....

Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t) + bx_2(t) \Leftrightarrow aX_1(f) + bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t - t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f - f_o)$
Time Convolution	$x_1(t) * x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f) * X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n} x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n} X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f} + \frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

Useful Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B) - \cos(A+B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta} - e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta} + e^{-j\theta}\right]$$

Continued .....

Table of Bessel functions of the first kind

	$J_n(\beta)$							
n	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1.0$	$\beta = 2.0$	$\beta = 3.0$	$\beta = 5.0$
0	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178
1	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328
2	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047
3		0.001	0.003	0.007	0.020	0.129	0.309	0.365
4				0.001	0.002	0.034	0.132	0.391
5						0.007	0.043	0.261
6						0.001	0.011	0.131
7							0.003	0.053
8								0.018
9								0.006
10								0.001

End of Paper